

# PATENT SPECIFICATION

829,409

DRAWINGS ATTACHED.

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## COMPLETE SPECIFICATION.

### Apparatus for Sampling Gas Expired by a Patient.

We, THE BOARD OF GOVERNORS OF THE UNITED BIRMINGHAM HOSPITALS, a Body Corporate under the provisions of the National Health Service Act, 1946, of the Secretary's Office, Queen Elizabeth Hospital, Edgbaston, Birmingham 15, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

During operations under an anaesthetic it is often desirable to be able to determine the carbon dioxide (or other gas) content of the gas within the patient's lungs which is closest to equilibrium with the arterial blood. To do this it is necessary to sample what is known as the "End-tidal gas", that is to say the gas which is expired by the patient after the "dead-space gas" (i.e. the gas in the upper respiratory tract which has not been drawn into the lungs) is expired.

The object of this invention is to provide apparatus for this purpose in a convenient and efficient form.

Apparatus according to the invention comprises in combination a breathing tube, an analyser, means for inducing a flow of gas from the breathing tube, or from the patient's respiratory tract to the analyser, a pressure sensitive device operable by the pressure differential between two spaced points in the breathing tube to initiate operative action of said means, and means for causing a predetermined but adjustable time lag between operation of said device and the inducing of a flow of gas to the analyser.

An example of the invention will now be described with reference to the accompanying diagrammatic drawing.

In the drawing 1 represents a breathing tube through which the patient is intended to inspire and expire, whilst 2 represents an analyser to which gas can be drawn through a tube 3 from the tube 1, or from the patient's respiratory tract. The analyser 2 may be of any convenient form adapted to measure the carbon dioxide, or other gas content of the gas passed to it, and incorporates a semi-permeable or other restrictive device whereby gas can only enter the analyser from the breathing tube 1, or the patient's respiratory tract when a flow is induced by other means. In the drawing the means for inducing this flow comprises a suction pump or fan 4 actuated by a source of electric power 5. Alternatively a pump or fan could be situated in the tube 3 between the analyser and the breathing tube 1, or the respiratory tract. Moreover, between the analyser and the pump or fan is connected a valve 6 actuatable by a solenoid 7.

Two spaced points in the breathing tube 1 are connected through a pair of tubes 8 and 9 respectively to opposite sides of a diaphragm 10 of a pressure sensitive switch 11, and the arrangement is such that the pressure differential acting on opposite sides of the diaphragm as the patient expires through the tube 1 will cause the switch to close.

The switch 11 is in series with an adjustable resistance 12 and the coil of a relay 13 which is connected to a direct current supply from the power source 5. Energisation of the relay 13 is adapted to close the switch 14, and to move the movable contact piece of the switch 15 from the position shown to the alternative position. Moreover, a condenser 16 and a resistance 17 are connected to the fixed contacts of the switch 15 as shown.

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When the patient expires through the breathing tube 1 the pressure differential at opposite sides of the diaphragm will cause the switch 11 to close. When the switch 11 is closed the condenser 16 is charged at a rate depending on the setting of the resistance 12 to provide a delay before actuation of the relay 13. When the relay 13 is actuated the switch 15 is changed from the position shown to discharge the condenser quickly through the resistance 17, and at the same time the switch 14 is closed to energise the solenoid 7 and thereby open the valve 6. Opening of the valve 6 will cause the suction pump or fan to be placed in operative connection with the analyser so that gas is drawn into the analyser from the breathing tube, or from the patient's respiratory tract. At the end of expiration the switch 11 opens and the parts return to the positions shown.

In use the resistance 12 is so adjusted that gas is only drawn into the analyser during the latter part of the expiration of the patient normally corresponding to the expiration of the final part of the "end-tidal gas". This finally expired portion of the "end-tidal gas" under normal circumstances has a composition substantially similar to the gas in the depths of the lungs, and therefore a relatively accurate indication of the carbon dioxide (or other gas) content of the gas in the lungs can be obtained in the analyser.

Since the flow of gas to the analyser 2 is initiated by the flow of gas from the patient, apparatus in accordance with the invention can be used during spontaneous or artificial respiration of the patient, and is usable in conjunction with anaesthetic apparatus, or independently. Further, by reversing the

connections of the tubes 8 and 9 sampling of gas from any part of the apparatus can, if desired, be effected during inspiration.

#### WHAT WE CLAIM IS:—

1. Apparatus for sampling gas expired by a patient comprising in combination a breathing tube, an analyser, means for inducing a flow of gas from the breathing tube, or from the patient's respiratory tract to the analyser, a pressure sensitive device operable by the pressure differential between two spaced points in the breathing tube to initiate operative action of said means, and means for causing a predetermined but adjustable time lag between operation of said device and the inducing of a flow of gas to the analyser.

2. Apparatus for sampling gas expired by a patient comprising in combination, a breathing tube, an analyser, means connected to the analyser for inducing a flow of gas thereto from the breathing tube or from the patient's respiratory tract, a valve between the analyser and said means, an electro-magnetically operated device for actuating said valve, a switch operable by the pressure differential between two spaced points in the breathing tube for closing a circuit to said electro-magnetically operated device, and means for causing a predetermined but adjustable time lag between the closing of said switch and actuation of the electro-magnetically operated device.

3. Apparatus for sampling gas expired by a patient comprising the combination and arrangement of parts substantially as described with reference to the accompanying drawings.

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#### PROVISIONAL SPECIFICATION.

#### Apparatus for Sampling Gas Expired by a Patient Whilst Under an Anaesthetic.

We, THE BOARD OF GOVERNORS OF THE UNITED BIRMINGHAM HOSPITALS, a Body Corporate under the provisions of the National Health Service Act, 1946, of the Secretary's Office, Queen Elizabeth Hospital, Edgbaston, Birmingham 15, do hereby declare this invention to be described in the following statement:—

During operations under an anaesthetic it is often desirable to be able to determine the carbon dioxide (or other gas) content of the gas within the patient's lungs which is closest to equilibrium with the arterial blood. To do this it is necessary to sample what is known as the "end-tidal gas", that is to say

the gas which is expired by the patient after the "dead-space gas" (i.e. the gas in the upper respiratory tract which has not been drawn into the lungs) is expired.

The object of this invention is to provide apparatus for this purpose in a convenient and efficient form.

Apparatus according to the invention comprises in combination a breathing tube in which is formed a constriction, an analyser to which gas is adapted to be drawn from the breathing tube or from the patient's respiratory tract when the analyser is subjected to a predetermined negative pressure, suction means for subjecting the analyser to a negative pressure, a valve between the analyser

and said suction means, and means operable by the pressure differential across the restriction in the breathing tube for actuating the valve.

5 In an example of the invention connected through tubing to the breathing tube through which the patient is adapted to inspire and expire is an analyser which may be of any convenient form adapted to measure the carbon dioxide (or other gas) content of the  
10 gas passed to it. This analyser incorporates a semi-permeable or restrictive device whereby gas can only enter the analyser from the breathing tube when the pressure in the  
15 analyser reaches a predetermined negative pressure.

The analyser is connected to a suction pump whereby it may be subjected to negative pressures, and between this pump and  
20 the analyser is a valve (hereinafter termed the control valve) which may conveniently be actuated by a solenoid. Further, between the control valve and the analyser is a manually adjustable valve, and between this valve  
25 and the analyser is connected a gas reservoir of adjustable volume.

In the breathing tube is a constriction, and at opposite sides of this constriction are connected a pair of tubes leading respectively to  
30 opposite sides of a pressure sensitive member, such as a diaphragm or piston. This pressure sensitive member is arranged to operate a switch in an electric circuit including the solenoid of the control valve.

35 The arrangement is such that as the patient expires through the breathing tube,

the pressure differential across the restriction causes the pressure sensitive member to move in a direction to close the switch. Closing of this switch actuates the control  
40 valve, thus placing the suction pump in communication with the analyser. The manually operable valve and the volume of the gas reservoir are so adjusted in relation to the capacity of the pump, and the breathing  
45 of the patient that the aforesaid predetermined negative pressure in the analyser is reached only during the latter part of the expiration of the patient, normally corresponding to the expiration of the final part  
50 of the "end-tidal gas". This finally expired portion of the "end-tidal gas" under normal circumstances has a composition substantially similar to the gas in the depths of the  
55 lungs, and therefore a relatively accurate indication of the carbon dioxide (or other gas) content of the gas in the lungs can be obtained in the analyser.

Since the flow of gas to the analyser is initiated by the flow of gas from the  
60 patient, apparatus in accordance with the invention can be used during spontaneous or artificial respiration of the patient, and is usable in conjunction with anaesthetic apparatus, or independently. Further, by reversing  
65 the connections of the tubes connecting the breathing tube with the pressure sensitive member sampling of gas from any part of the apparatus can, if desired, be effected  
70 during inspiration.

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# 829,409 COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of the Original on a reduced scale.*

